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(19)

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(54) MEASURING APPARATUS

(71) We, THE SHOE AND ALLIED TRADES RESEARCH ASSOCIATION, a British company, of Satra House, Rockingham Road, Kettering, Northants., England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the measurement of human feet.

Various forms of apparatus have already been proposed for the measurement of human feet to obtain an indication of appropriate shoe size. Reference may be made, for example, to U.K. Patent Specification Nos. 593,311; 999,440; 1,028,361; and 1,416,919.

In one aspect, the present invention provides apparatus for measuring a human foot to obtain an indication of appropriate shoe size, comprising means defining a zone in which the foot is to be located during measurement, said zone defining means comprising a support on which the foot is to be placed and a first and a second datum extending at right angles to each other for defining the position of the foot upon the support; means for passing light energy through said zone; scanning means operable to scan said zone and responsive to said energy for producing first and second signals dependent respectively upon the distance between said first and said second datum and the points most distant therefrom at which said energy is interrupted, said signals thereby being produced respectively in dependence upon the length and width of the foot to be measured; and means coupled to said scanning means for indicating the size of shoe appropriate to said foot in dependence upon said first signal and said second signal.

In another aspect, the present invention provides a method of measuring a human foot to obtain an indication of appropriate shoe size, comprising placing the foot against a first datum and a second datum which extend at right angles to each other and one of which defines the inside tangent of the foot; passing light energy through the zone containing the foot; scanning the zone and detecting the points most distant from said respective first and second datum at which said energy is interrupted by said foot; producing, in response to said detection, electrical representations of the length of said foot and the width thereof as measured from the inside tangent, and deriving from said electrical representations an indication of the size of shoe appropriate to said foot.

Thus, in the invention, measurement may be achieved substantially automatically without the need for any feelers which are displaced into engagement with the foot being measured.

The invention is described further by way of example with reference to the accompanying drawings in which:

Figure 1 is a diagram of a human foot showing the dimensions to be measured;

Figure 2 is a perspective view of apparatus according to an embodiment of the invention, in use;

Figure 3 is a diagrammatic plan view illustrating one form of scanning means which may be embodied in the apparatus of Figure 2;

Figure 4 shows a part of the apparatus of Figure 2 on an enlarged scale;

Figure 5 is a diagram illustrating control circuitry employed in the scanning means of Figures 3 and 4;

Figure 6 is a block diagram illustrating logic for obtaining a display of length, suitable for the mondopoint shoe sizing system, utilising the scanning means of Figures 3 to 5;

Figure 7 is a block diagram illustrating logic for obtaining a display of width suitable for the mondopoint shoe sizing system utilising the scanning means of Figures 3 to 5;

Figure 8 is a block diagram illustrating further logic which may be employed additional to that shown in Figures 6 and 7;

have been shown in Figure 3 as arranged in a single row, in practice, the required spacing between the cells may be too small, in view of the size of commercially available photocells, to arrange them in this way. Therefore, in practice, the cells may in fact be arranged in a number of staggered rows, for example three rows, as shown in Figure 4, in which cell W2 is shown as displaced transversely of the bar 22 relative to the cell W1, and cell W3 is also displaced, relative to the cell W2, transversely of the bar 22. Cell W4 is aligned with cell W1 and cells W5 and W6 are aligned respectively with cells W2 and W3 in the longitudinal direction of the bar 22. The arrangement of the cells is such that the spacing between the centres of each adjacent pair of cells is the same, this spacing being indicated in Figure 4 by the reference character *w*, as measured longitudinally of the bar 22 i.e. as measured parallel to the direction of the width W of the foot to be measured.

In the proposed mondopoint system, the size of shoe is to be indicated by two numbers, the first of which is the length L in millimetres and the second of which is the width M in millimetres, these numbers to be written in the form L/M to designate a particular shoe size. It is also proposed that the interval between two adjacent sizes in mondopoint should be either 5 mm or 7½ mm. For example, a typical range of women's shoes with a 5 mm interval between sizes, and of average width might be as follows:

L=215 mm, M=82 mm written as 215/82
L=220 mm, M=84 mm written as 220/84
L=225 mm, M=86 mm written as 225/86
etc.

In the case where a 7.5 mm interval is chosen, figures after the decimal point would be omitted from the marking. A typical range again for women's shoes might be as follows:

L=217.5 mm, M=83 mm written as 217/83
L=225 mm, M=86 mm written as 225/86
L=232.5 mm, M=89 mm written as 232/89
etc.

In order to be able to measure intervals of both 5 mm and 7.5 mm, the spacing between the centres of each adjacent pair of cells L1 to LN is, in the present embodiment, 2½ mm, this providing, as will be apparent, sufficient resolution for dealing with shoes with 5 mm and 7.5 mm intervals between sizes.

In the case of the dimension M, it is desired to have a resolution which will give readings to within 1 mm. Since it is the width W which is actually to be sensed by the apparatus, the resolution in the direction of the width W should therefore be 1 mm × sin 70, i.e. the spacing *w* between the centres of adjacent cells W1 to WN should be 1 mm × sin 70.

The reference numerals W1 ... WN indicate the photocells for sensing the width W of the right foot. The reference number 30 has been indicated on Figure 3 to indicate generally the photocells for sensing the width W of the left foot, but these are not individually referenced.

The motor 26 is arranged to effect movement of the bar 22 in the direction of the arrow 32, namely parallel to the row of cells L1, LN. Each measuring operation begins with the bar 22 in the position shown in Figure 2. Measuring is effected by energising the motor to cause it to move the bar in the direction of the arrow 32. At the completion of the measurement the motor is reversed to return the bar 22 to the position shown in Figure 2.

Referring to Figure 5, when the operating button 14 is pressed, a reset circuit 34 for resetting the measuring logic to be described hereinafter to a condition ready for starting a new measuring operation is energised, and a motor control circuit 36 is also energised so that the motor drives the bar 22 in the direction shown by the arrow 32. The bar continues to move in this direction until it engages a limit switch LS1 defining the extremity of its movement. Engagement of the limit switch LS1 signifies completion of the scanning movement of the bar 22, and thereupon the direction of drive of the motor is reversed so as to return the bar to the position shown in Figure 2. The motor is stopped when the bar 22 engages a second limit switch LS2 defining the starting position of the bar 22 shown in Figure 3.

MEASUREMENT OF LENGTH.

As shown in Figure 6, the photocells L1 to LN are connected through an OR gate 40 and a multiplier circuit 41 having a multiplication factor of 2.5 to one input of a length counter 42 and the photocells W1 to WN are connected through an OR gate 44 to another input to the counter 42. Thus, each pulse received by the counter 42 from the circuit 41 represents movement of the bar 22 through one millimetre. The reset circuit 34, when energised, causes a number equal to the maximum possible length in millimetres which can be measured to be read into the counter 42 from a "maximum length store" 46 i.e. the distance in millimetres of cell L1 from the datum 8. The photocells L1, LN are normally illuminated, either from the ambient illumination referred to above or if desired from a special light source located in the housing 2, and the bar 22 is arranged so that as it scans in the direction of the arrow 32 it interrupts light to the photocells L1 to LN in turn. This interruption causes

would measure only 2 cm in length. There may be 512 diodes in the array.

The array 100 is mounted on the bar 22 as shown in Figure 9, and a lens 102 also carried by the bar 22 is mounted above the array 100 so as to focus thereon a strip image of the appropriate portion of the platform 4*b*. For the measurement of mondopoint, and assuming the centre spacing of the diodes in the array 100 is .2 mm, the lens 102 is a diminishing lens which is such that two points spaced apart by sin 70×1 mm on the platform 4*b* will be spaced apart, in the image focussed on the array 100, by only 0.2 mm. Since the image will be inverted by the lens, the individual cells of the array 100 are indicated as arranged in the opposite order in Figure 9 to that shown in Figures 3 and 4. Thus, the apparatus of Figure 9 operates in the same way as described with reference to Figures 2 to 8.

Figure 9 also shows a light source 110 for illuminating the cells L1 to LN.

In the embodiment of Figure 9, the array 100 and lens 102 are of course repeated for measurement of the left foot, even though this is not shown in the drawings.

MEASUREMENT IN ENGLISH SIZING.

Conventional English shoe sizes are designated as an integral number or an integral number plus a half. The number designating a particular size is based upon the length L of the foot, although it is not a representation of that length in any commonly used units of length such as inches or centimetres. Furthermore, different sizings are used for men's, women's, young people's (youths) and children's shoes. Thus, when stating a particular size it is necessary to state whether it is for a man, a woman, a youth or a child. Since simply saying, for example, size nine, will not be sufficient.

Also, although different widths (fittings) of shoe are available for each designated size, such widths are not normally indicated as a number, but rather simply designated as a "standard" fitting, or a "wide" fitting or a "narrow" fitting.

Although the ideal shoe would be precisely defined in terms of length (size) and type of fitting, it has been found possible, in order to reduce the range of sizes which have to be provided, to adequately fit most people simply by providing shoes of the different sizes but all of standard fitting and, if an individual finds that he needs a size X of wide fitting instead of standard fitting he may usually find size X½ standard fitting satisfactory. This is because a standard fitting size X½ is wider than a standard fitting size X.

The embodiment of the invention now to be described is for use in determining the size of shoe required from a range in which all sizes are available only in standard fitting. Feet of non-standard width being accommodated by adjusting the size as just described. In fact in the following embodiment, provision is made for adjusting the size upwards by one half unit or one whole unit for accommodating feet which are respectively of wide fitting and extra wide fitting, and for adjusting the size downwardly by one half unit for accommodating a foot which is of narrow fitting.

In Figure 10, the maximum length and maximum width counters 42M and 52M are shown. The width display 64 is omitted, but the length display 48 is provided.

The logic of Figure 10 includes minimum and maximum width stores 70 and 72 which, for each possible length of foot, contain respectively the lower limit and the upper limit of width W of foot which should be fitted into a shoe of standard fitting. These limits are effectively measurements corresponding to the sizes of shoe manufactured or available at the shop. Further stores 74 and 75 have in them respectively, for each possible length, the maximum width W of foot which can be fitted if the length recorded in the counter 42M is increased by one ½ unit and one whole unit of size respectively. A store 77 has in it the minimum width W of foot which should be fitted if the length recorded in counter 42M is decreased by one ½ unit of size.

The circuit of Figure 10 is energised when the bar 22 reaches the limit switch LS1 and, initially, the length recorded in the counter 42M is used to control transfer gates 76 so that the corresponding numbers from the stores 70, 72, 74, 75 and 77 are transferred to respective temporary stores 78, 80, 82, 83 and 85. A comparator 84 then compares the number in the counter 52M with the numbers in the temporary stores 85, 78, 80, 82 and 83 in turn.

If the number in counter 52M is equal to or greater than the number in the store 78 and less than or equal to the number in the store 80, the comparator causes the number recorded in the counter 42M to be displayed on the length display 48 and the customer will choose a shoe according to this length.

If the number in the counter 52M is less than that in the store 78 but not less than that in the store 85, the comparator causes the length recorded in the length counter 42M to be decreased by one ½ unit of size and the resulting size to be displayed on the length display 48. The customer would then choose a shoe which is in fact one ½ size smaller than he would expect to have required, having regard to the length of his foot, but since his foot has been shown to be narrower than standard, it is likely that the one ½ size smaller shoe will in fact fit.

TABLE 1

Men's Sizes

Shoe sizes corresponding to measured length L	Corresponding Number in Store:				
	77	70	72	74	75
5	87.3	89.8	92.1	94.6	97.1
5½	88.3	90.8	93.1	95.6	98.1
6	89.2	91.7	94.1	96.5	99.0
6½	90.2	92.7	95.1	97.5	100.0
7	91.2	93.6	96.0	98.5	100.9
7½	92.2	94.6	97.0	99.5	101.9
8	93.1	95.6	97.9	100.4	102.9
8½	94.1	96.6	98.9	101.4	103.9
9	95.0	97.5	99.9	102.3	104.8
9½	96.0	98.5	100.9	103.3	105.8
10	97.0	99.4	101.8	104.3	106.7
10½	98.0	100.4	102.8	105.3	107.7
11	98.9	101.4	103.7	106.2	108.6
11½	99.9	102.4	104.7	107.2	109.6
12	100.8	103.3	105.6	108.1	110.6
12½	101.8	104.3	106.6	109.1	
13	102.7	105.2	107.5		

TABLE 3

Youths' Sizes

Shoe sizes corresponding to measured length L	Corresponding Number in Store':				
	77	70	72	74	75
½		70.9	73.2	75.6	78.0
1	70.0	72.4	74.7	77.1	79.5
1½	71.4	73.8	76.1	78.5	80.9
2	72.8	75.2	77.5	79.9	82.3
2½	74.2	76.6	78.9	81.3	83.7
3	75.7	78.1	80.4	82.8	85.2
3½	77.1	79.5	81.8	84.2	86.6
4	78.5	80.9	83.2	85.6	88.0
4½	80.0	82.4	84.7	87.1	89.5
5	81.4	83.8	86.1	88.5	90.9
5½	82.8	85.2	87.5	89.9	92.3
6	84.2	86.6	88.9	91.3	93.7
6½	85.6	88.0	90.3	92.7	95.1
7	87.1	89.5	91.8	94.2	96.6
7½	88.5	90.9	93.2	95.6	98.0
8	89.9	92.3	94.6	97.0	
8½	91.3	93.7	96.0		

are such as to be able to record half units.

In the case of width measurement, it is necessary that the system should have a resolution which is capable of distinguishing points on the platform 4*b* spaced apart by .366 mm in the case of children's feet; 1.23 mm in the case of women's feet; and .48 mm in the case of men's and youths' feet. If the instrument is to be capable of measuring all of men's, women's, children's and youths', therefore, it is necessary to take the highest common factor of these numbers to determine the resolution necessary in a machine which is to be capable of measuring all feet. The highest common factor is .12 mm, and accordingly, in the present embodiment, the measuring apparatus is such that points spaced apart .12 mm on the platform 4*b* are detected. If the arrangement of Figure 4 were used, therefore, the spacing *w* between the photocells W1 to WN would have to be .12 mm. This is rather impractical in view of the physical size of conventional photocells, and therefore it is preferred in this embodiment that the arrangement of Figure 9 be used. With this arrangement, assuming the spacing between the photodiodes of the array 100 (as measured centre to centre) is .2 mm, the lens 102 should be arranged so that .2 mm in the image focussed on the array corresponds to .12 mm in the plane of the platform 4*b*.

In order to convert the number selected by the select logic 68 from a number representing the width of the foot in units of .12 mm, therefore, it is necessary to divide this number by .12 before it is recorded in the width counter 52M in the embodiment of Figure 10. Accordingly, a division circuit 150 is shown in Figure 10 as connected between the select logic 68 and the width counter 52M.

Figure 10 also shows an operator control switch 152 connected to the transfer gates 76. This switch 152 has to be set by the user of the apparatus to either "mens", "womens", "youths", or "childrens" before the apparatus is operated so that the appropriate number will be selected for storage in the temporary stores 78, 80, 82, 83 and 85 as defined in the above tables 1 to 4 according to whether the person whose feet are being measured is a man, woman, youth or child.

Figure 10 has been described on the assumption that it is used in conjunction with the circuitry of Figure 8. If desired, the circuitry of Figure 10 could be duplicated so as to give independent displays of length for the left and right feet, in which case the logic of Figure 8 would not be employed.

VARIATIONS AND MODIFICATIONS.

Numerous variations and modifications are possible within the scope of the invention. For example, although the instrument of Figure 10 has been described as being capable of measuring men's, women's, youths' and children's feet, it would be possible to design such an instrument capable only of use with a selected one out of these different types of feet. In this case, it would only be necessary, in the width measurement, for the resolution to be capable of distinguishing points .366 mm apart in the case of children's feet; 1.23 mm apart in the case of women's feet, and .48 mm apart in the case of men's and youths' feet. Thus, if the resolution of .366 mm is chosen in designing an instrument for measuring children's feet, then the division factor of circuit 150 would be .366 instead of .12. If a resolution of 1.23 is chosen for an instrument for measuring women's feet, the division factor would be 1.23 in the circuit 150; and if a resolution of .48 mm is chosen for an instrument for measuring men's and youths' feet, then the division factor of circuit 150 would be .48. There is no reason, however, why even in an instrument for measuring only one type of foot the resolution should not be maintained at .12 mm in which case the division factor of circuit 150 would be kept at .12. Thus with any of these arrangements, it is ensured that when the numbers stored in the stores 70, 72, 74, 75 and 77 are in millimetres, the number recorded in the width counter 52M is also always in millimetres.

The width measuring circuit of Figure 7 employs a register 50 comprising a number of bistable stores. If it is desired to eliminate the necessity for such stores, the circuit could be re-designed so that the photocells W1 to WN are continuously scanned during movement of the bar 22 and storage means could be provided so as to store a number which corresponds to whatever is the right-most one of the cells W1 to WN which has produced a signal in the case of measuring the right foot (or the left-most in the case of measuring the left foot). This may be achieved by connecting the cells W1 to WN to a multiplexer, causing the multiplexer to continuously scan the cells, or to scan them at selected incremental movements of the bar 22, and to feed the output of the multiplexer into a counter. Comparator means would be provided to compare the contents of the counter after each scan with the contents thereof at the end of the previous scan so as to determine the maximum width of the foot i.e. the widthh W.

Although arrangements involving photocells have been used as sensing means for the feet, any other form of sensing means may be employed. For example a television camera could be employed provided a camera with a high resolution is selected and with a high degree of linearity in the scan so as to give accurate readings.

In the case of the mondopoint instrument which has been described, the arrays of cells

in dependence upon the wider of said feet.

3. Apparatus according to claim 2, wherein said scanning means comprises a first detector device movable to scan said first and second zones to produce said single first signal; and a second detector device movable at right angles to said first detector device for scanning said first and second zones to produce said two second signals.

4. Apparatus according to claim 2 or 3, wherein said means for passing light energy through said zone is a single source of light energy located at a fixed position and arranged to supply said energy through both of said zones simultaneously.

5. Apparatus according to any preceding claim, wherein said light energy is visible light.

6. Apparatus according to any of claims 1 to 5, wherein each said datum comprises an upstanding surface.

7. Apparatus according to any preceding claim, wherein said means for passing light energy through said zone is located above said zone, and said scanning means is located below said zone.

8. Apparatus according to any of claims 1 to 7, wherein said indicating means is operative to indicate said zone in English units of size.

9. Apparatus according to any of claims 1 to 7, wherein said indicating means is operative to indicate said size in English units of size, without any indication of fitting, said indicated size being in accordance with said measured length if said measured width is within predetermined limits but being greater or less than said measured length, by a predetermined amount, if said measured width is above or below said predetermined limits by a predetermined amount.

10. Apparatus according to any of claims 1 to 7, wherein said indicating means is operable to indicate said size in the form of a first number which is equal to said length in millimetres and a second number which is equal to sine 70° of said width in millimetres.

11. A method of measuring a human foot to obtain an indication of appropriate shoe size, comprising placing the foot against a first datum and a second datum which extend at right angles to each other and one of which defines the inside tangent of the foot; passing light energy through the zone containing the foot; scanning the zone and detecting the points most distant from said respective first and second datum at which said energy is interrupted by said foot; producing, in response to said detection, electrical representations of the length of said foot and the width thereof as measured from the inside tangent, and deriving from said electrical representations an indication of the size of shoe appropriate to said foot.

12. A method according to claim 11, wherein the left and right feet are each positioned against a respective first and second said datum, a said electrical representation of length is produced only for whichever is the longer of said feet, an electrical representation of width is produced for each of said feet, and said indication is derived from said electrical representation of length and whichever is the larger of said electrical representations of width.

13. Apparatus for measuring a human foot, substantially as herein described with reference to Figures 1 to 7 of the accompanying drawings.

14. Apparatus for measuring a human foot, substantially as herein described with reference to Figures 1 to 7 and as modified by Figure 8 of the accompanying drawings.

15. Apparatus for measuring a human foot, substantially as herein described with reference to Figures 1 to 7 and as modified by Figure 9 of the accompanying drawings.

16. Apparatus for measuring a human foot, substantially as herein described with reference to Figures 1 to 7 and as modified by Figure 10 of the accompanying drawings.

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Fig. 2

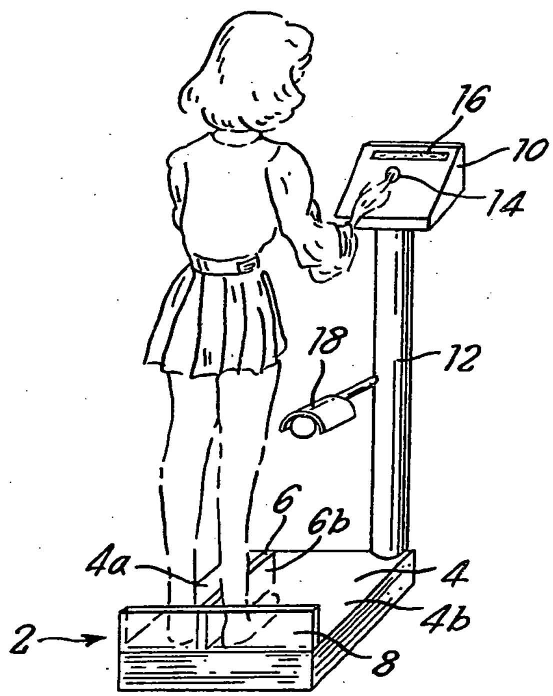

Fig. 4

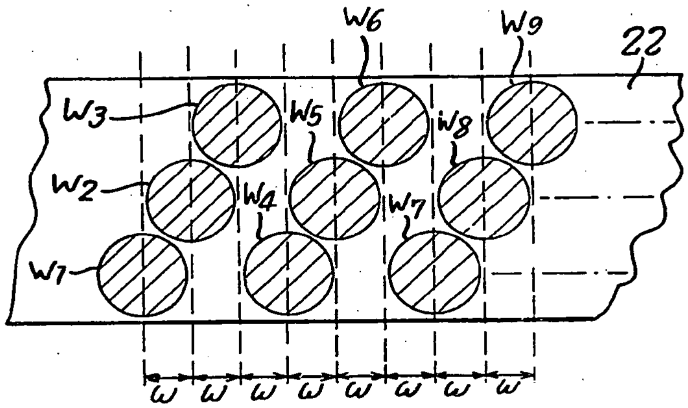
W6
W9
22
W3
W5
W8
W2
W4
W7
W1
ω ω ω ω ω ω ω ω

Fig. 5

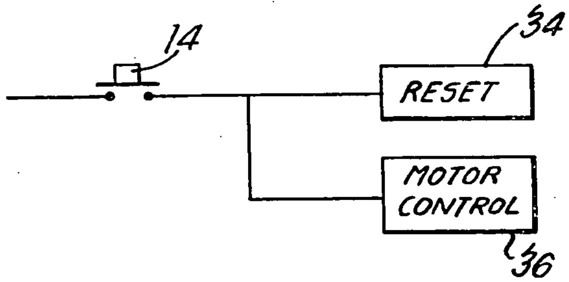
14
34
RESET
MOTOR CONTROL
36

Fig. 7

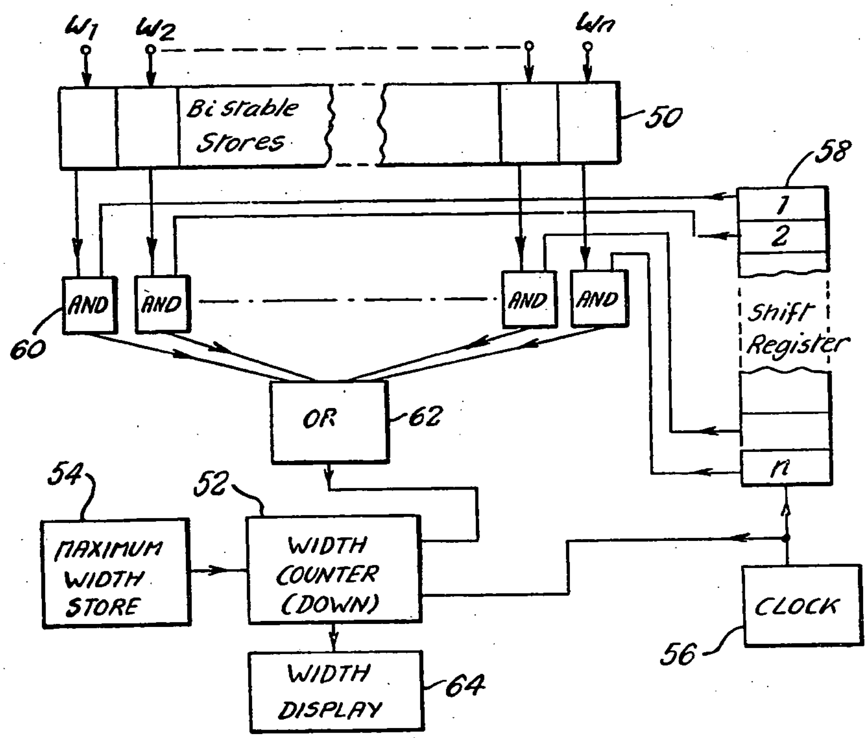
W1
W2
Wn
Bi stable Stores
50
58
1
2
AND
AND
AND
AND
Shift Register
60
n
OR
62
54
52
MAXIMUM WIDTH STORE
WIDTH COUNTER (DOWN)
CLOCK
56
WIDTH DISPLAY
64

Fig. 9